TEMPERATURE RELATIONS BETWEEN THE TWO CHICAGO, ILL., WEATHER BUREAU STATIONS: CAMPUS OF THE UNIVERSITY OF CHICAGO AND THE ROOF OF THE UNITED STATES COURTHOUSE

By C. A. DONNEL

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(NOTE: All temperatures are in Fahrenheit degrees)

There are now available 16 years' synchronous records obtained at the Weather Bureau stations: (1) University of Chicago; (2) roof of the United States courthouse (formerly the Federal building), Chicago, Ill. These stations are about 7 miles apart, and distant from Lake Michigan 1 mile and 7/10 mile, respectively.

The dimensions of the thermometer shelter at the university are 36 by 38 by 50½ inches. Its location on the campus is on the quadrangle about which are grouped Rosenwald Hall (Walker Museum), to the north; a long building housing women's dormitories, to the east; the social sciences building, to the south; and the law building, to the west. All these buildings are 71 feet in height and their respective distances from the shelter are 92, 83, 171, and 91 feet.

Three of these buildings were erected before the temperature records were begun, but the social sciences building dates only from 1929–30. The quadrangle is open to the flow of outside surface air for a width of 61 feet at the northeast corner, 23 feet at the northwest, 19 feet at the southwest, and 23 feet at the southeast. The shelter stands over sod. The elevation of its floor is 6 feet, and the thermometers inside are two feet above the floor. The exposure may be regarded as suitable for representing residential conditions in a large city. However, it should be pointed out that Lake Michigan exercises a profound influence at both exposures, because during an average year the wind blows from off the lake 42 percent of the time. One important effect of this lake wind is the lowering of the mean daily range in temperature at these stations to only 15°, whereas in the western part of the city, 8 or 9 miles away from the lake, the range is about 20°. A few miles farther west the range is still greater, approximating 22°.

The dimensions of the thermometer shelter at the United States courthouse, which, like the one at the university, also has a peaked roof, are 39 by 42 by 54 inches. It stands on the slate-in-cement roof of the 8-story north wing of the courthouse, and its floor is 10 feet above the roof, or 139 feet above the street level. The dome of the courthouse rises 168 feet above this roof and is 42 feet south of the shelter. Fourteen feet west of the shelter is a north-south skylight, the ridge of which is 9 feet, and the eaves 3 feet, above the roof. High buildings surround the shelter and, with the dome of the United States courthouse, keep it in the shade at various times. The exposure is typical of those used to obtain atmospheric temperatures on the roof of a building in the heart of the business district of a large city.

For the entire 16 years of comparative records the annual mean temperature at the university averages exactly 1° lower than the United States courthouse mean. In each the means were lowest at the university. The greatest difference was 1.3°, in 1919 and 1920, and the least, 0.7° in both 1932 and 1933.

The annual means of the daily maximum temperatures averaged 0.5° lower at the university than at the courthouse. The greatest difference was 0.9°, in 1925, and the least, 0.2°, both in 1922 and 1933.

The annual means of the daily minimum temperatures show that the university was colder by 1.6°, and also colder each year. The greatest difference was 1.2°, in 1926, 1932, and 1933.

The fact of the occurrence of the least differences, both for the annual mean daily maximum and annual mean daily minimum temperatures in 1933, arouses the suspicion that the enclosing of the quadrangle by the erection of the social sciences building in 1929–30 has resulted in slightly higher temperatures at the university station. However, as already pointed out, we find that the least difference both for the mean daily maximum and mean daily minimum temperatures occurred also in 1922 and 1926, respectively, when the south side of the quadrangle was still open.

CONSIDERATION OF THE DATA BY MONTHS

The monthly mean temperatures were lower at the university in every one of the 192 months of record except April 1927, when they were identical. The greatest differences in the means occurred in midwinter and midsummer, and the least, in spring and late fall. July shows that the greatest difference for any individual month was 2.1°, in September 1928, while, as indicated above, the least was for April 1927, 0.0°.

The averages of the monthly maximum temperatures were lower at the university, except for September and October, when slight excesses of 0.3° and 0.1°, respectively, occurred. The difference was greatest in January, 1.2°, with the greatest difference for any individual month, 2.0°, both in January and February 1925. On the other hand, the greatest excess of the university over the courthouse was 1.1°, in September 1922. Perhaps the comparatively large differences that prevail in the winter months were caused by the "city effect." That is to say, the maximum thermometer at the courthouse was more affected by heat from the buildings than was the maximum thermometer at the university. On the other hand, the excess shown in September and October at the university can best be explained by the fact that at that time of the year there is a reduced wind movement from the lake and at the same time not much "city effect" on the courthouse thermometer. As has already been pointed out, the courthouse maximum thermometer is somewhat nearer the lake than is the university thermometer and is thus affected by lake winds slightly more than is the latter.

For all 12 months the mean minimum temperatures averaged lowest at the university. The differences were greatest in July, August, and September, 2.2°, 2.5°, and 2.4°, respectively, while they were least in late winter and early spring, 0.9°, for February, March, and April each. Doubtless the larger differences in late summer and early fall are due in part to the occurrence of good radiation conditions at that time and in part to the fact that the nighttime winds off the lake at that season are comparatively warm. The greatest difference in the means for any month was 4.0°, in September 1928, while

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the least difference was 0.0°, both in February and April 1932.

The annual mean temperatures at the two locations appear to be slightly less divergent in recent years than in the years at the beginning of the records. For the first 4 years the average difference was 1.2°, whereas for the last 4 years it was 0.8°. That this change has been brought about almost wholly by more nearly equal minimum temperatures is revealed by the fact that the average annual mean daily maximum temperatures for the first 4 years of record were 0.5° lower at the university, and for the last 4 years 0.4° lower, whereas the mean daily minimum temperatures were 1.8° lower at the university for the first 4 years, but only 1.3° lower for the last 4. Whether this discrepancy of 0.5° is due to the use of different minimum thermometers having unlike corrections that were not applied, to the erection of the social sciences building, or to something else, is uncertain. Possibly the differences are of a wholly natural character.

Finally, the most interesting result in this comparison is the fact that these two stations, only 7 miles apart and with about the same influence exercised on each by a large body of water, show divergences in the differences between their monthly mean temperatures of 1° or more in 9 of the 12 months. This divergence is greatest, 2°, in September. Even the annual mean temperature itself shows a divergence of 0.6°. And, of course, even larger divergences appear both for the monthly mean daily maximum and mean daily minimum temperatures, ranging for the mean maximum temperatures from 1° in December to 1.8° in February, and for the mean minimum temperatures from 1.3° in June to 3.1° in September. These facts show what uncertainty may exist when interpolating for missing records. If these comparatively large divergences exist for stations as close together as 7 miles it is reasonable to assume that as large or even larger divergences exist for stations farther apart, as, for example, in the case of two cooperative stations 25 or 30 miles apart.

METEOROLOGICAL CONDITIONS AND WHEAT YIELDS IN FORD COUNTY, KANS.

By CLARENCE E. KOEPPE

[Southwest Missouri State Teachers College, Springfield, Mo., Apr. 24, 1934]

There have been numerous studies made of the relation of weather conditions to crop yields—many quantitative but most of them only qualitative. Several quantitative studies of *wheat* yields and weather conditions have been made during the past 20 years, notably by J. W. Smith, particularly in Ohio, and by Hessling in the Argentine. There is, however, marked disagreement in almost all of the studies, which have been made, due probably to at least two causes: (1) The difference in geographic location and consequently in physical conditions. For example, rainfall seems to be less critical in Ohio than in Kansas, because in Kanass available moisture frequently is insufficient, while in Ohio wheat rarely suffers from lack of moisture; (2) the interrelations of the meteorological elements are so complex that it is difficult to establish whether, for example, a poor yield of wheat is due to too little rain in September, too high temperatures in October, lack of snowfall in January, too much rain in April, too strong winds in May, or whatnot else. There are discussed here only a few of the more apparent, though perhaps less real, relationships between yields of wheat and the elements of temperature (including maximum and minimum), rainfall, snowfall, rainy days, and wind velocities. No account has been taken of frost, hail, ice storms, sunshine, and cloudiness; and only slight consideration has been given to frequencies and sequences of weather elements.

The original plan was to select long-period data for at least three counties in Kansas, and to calculate partial and multiple correlations. Obviously the task was too great. Hence, and unfortunately so, this paper deals only with a 10-year period, 1921–30, for yields of wheat in Ford County, Kans., and with the meteorological data for the corresponding 10-year period at the county seat, Dodge City, which are assumed to be representative of those of the area in question. The meteorological year was taken from August 1 to July 31, rather arbitrarily to be sure, yet not entirely without justification since some wheat is harvested in July. Probably rainfall in July, however, has as much to do with the wheat crop the following year as it does with that of the same year.

The methods employed in arriving at the conclusions which follow were the usual ones, viz, the plotting of the data to note any marked correlations and in order to determine whether the relationship between the wheat yields and each of the several weather elements was linear or otherwise; the calculation of mainly simple correlation coefficients, with some partial and multiple correlations; the calculation of the probable error; and so on. In some instances there was very definite linear relationship; in others the points were so scattered that even a parabola failed to fit them. The attempt here, however, is not to discuss methods of correlation, but merely to point out a few of the more significant and striking relationships which seem to exist between the meteorological conditions by months and the wheat yields the following season.

There is a general impression that rainfall is the most critical factor in the production of winter wheat in central and western Kansas. Results of this study failed to show any such outstanding connections. Probably the most significant relationship was the fact that fairly moist Augusts, Septembers, Octobers, Januarys, and Februarys, and distinctly dry Aprils were followed by good yields of wheat the following Junes or Julys. The exceptionally low yields of 1925 and 1927 were preceded by April rainfall above normal, while the exceptionally high yields of 1926 and 1928 were preceded by April rainfall below normal. The low yield of 1923, which was 6 bushels to the acre when only one-fourth of the normal acreage was harvested, was preceded by a dry April, but by a May in which the rainfall was three times the normal amount. Conparison of wheat yields with the longest rainless intervals in the March-to-May period gave a negative correlation of 0.32, which figure has little if any significance. There was even less correlation when the period was extended from February to June, inclusive. A large number of rainy days in August and October seemed to be favorable for large yields the following year.

The total yearly snowfall showed a correlation of +0.50. April snowfall showed a relatively high correlation of +0.71, although this high figure may be due to too scattered data, many Aprils having no snow; that is, the yields of wheat may have been large in spite of April snowfall rather than because of it. Snow in February seemed to be desirable, more so than in March; but snowfall in November and December correlated negatively,